IH Exposure Assessment: UITF, Sulfur hexafluoride (SF_6)

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Introduction

A sulfur hexafluoride (SF_6) tank houses the Glassman gun high voltage power supply within the Upgraded Injector Test Facility (UITF). The SF6 is an insulating gas for the gun high voltage power supply. SF_6 is a colorless, odorless gas with a vapor density five times heavier than air. The primary hazard for SF_6 is asphyxiation (Praxair, 2015) as a result of displacement of oxygen. Since the gas is 5 times heavier than air, the gas will accumulate along the floor and low areas creating an oxygen deficiency hazard area, defined as an area where the oxygen concentration is less than 19.5%.

SF_6 is chemically inert; however, toxic contaminants such as sulfur pentafluoride and sulfur tetrafluoride can be present in technical grade gas (Sulfur Hexafluoride - TLV documentation, 2001) or when the gas is subjected to electrical discharge (Compressed Gas Association, 1999).

The Glassman power supply located in Cave 1 contains 45 lbs. (25 ft^3 @ 60 psi) of SF_6. Cave 1 and Cave 2 are open to each other and not separated by walls or other structures as shown in figure 2.

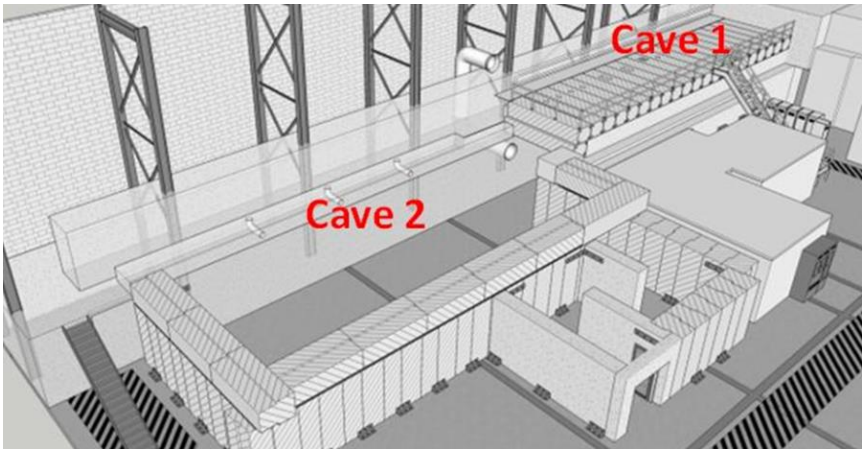

Figure 1: UITF layout shown with entrance labyrinth and Cave 2 roof removed.

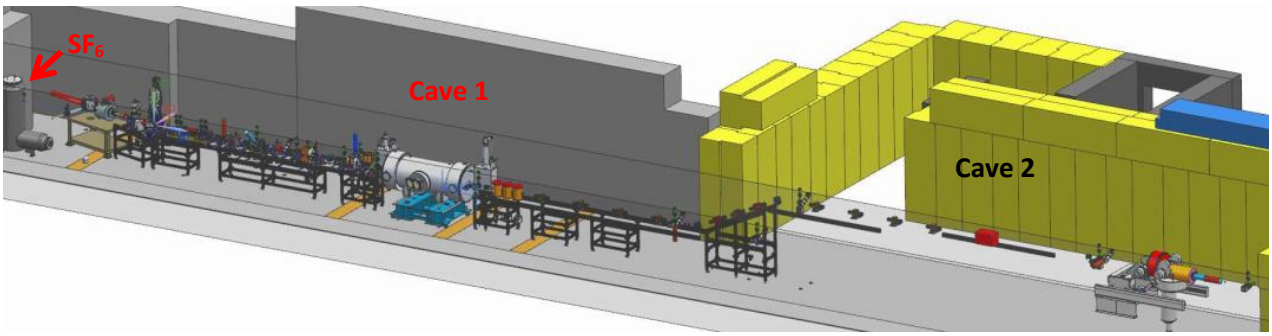

Figure 2: UITF layout with SF_6 location shown.

This assessment analyzes hazards of oxygen deficiency hazard, related to displacement of oxygen and ensures that the ACGIH threshold limit value (TLV), 1000 ppm (ACGIH, 2005) averaged over an 8-hour shift, is not exceeded for staff entering and working in the UITF. Two scenarios are analyzed in this assessment: 1) release of the gas into Cave 1 assuming no diffusion into Cave 2 and 2) release into the total volume of Cave 1 and Cave 2.

IH Calculations

Table 1: Worst case contaminant & oxygen concentration (total release of SF_6)

Location	Quantity of SF_6 (lbs.)	Volume of SF_6 (ft^3)	Volume of location (ft^3)	% Oxygen in case of release *	SF_6 concentration in case of release *
Cave 1	45	111	18,252	20.8%	6082 ppm
Cave 1&2 combined	45	111	30,942	20.8%	3587 ppm

** Resulting concentration assumes perfect mixing of released gas with air throughout the location*

Table 2: Height of accumulation from floor after initial release

Location	Volume of gas (ft^3)	Surface area of room (ft^2)	Resulting plume height on floor
Cave 1	111	1404	1 inch
Cave 1&2 combined	111	2461	0.6 inches

Table 3: Potential staff exposure

Location	SF_6 concentration in air	TLV exposure limit	Allowable exposure time in case of total release of SF_6
Cave 1	6082 ppm	1000 ppm	1 hour
Cave 1&2 combined	3587 ppm		2 hours

Discussion

Release scenarios show that the resulting SF_6 concentration exceeds the occupational exposure limit of 1000 ppm when accounting for the release into Cave 1 and when combining the total volume of Cave 1 and Cave 2 as shown in Table 1. These scenarios assume perfect mixing of the contaminant with air, however since the density of SF_6 is 5 times heavier than air it is assumed that the gas will fall to the floor. The maximum height from the floor after initial release is no more than 1 inch from floor level in in the reference locations (see Table 2). The area of highest concentration remains along the floor and risk to personal breathing zone is reduced unless a person is working at low levels or in the immediate vicinity of an active leak.

An exposure would result in exceedance of the TLV exposure limit only if a person were lying on the floor for more than 1 hour in the UITF after total loss of the SF_6 gas. ACGIH does allow for a one time excursion up to but not exceeding 5 times the TLV for a one-time exposure during a work day. In the case of SF_6 the excursion limit would be 5000 ppm, which is greater that the resulting concentration of 3587 ppm when accounting for the total volume of Cave 1 and Cave 2.

Resulting oxygen concentrations are within acceptable limits as calculated in Table 1.

Hazard Controls

The Accelerator Division's Center for Injectors and Sources Operational Safety Procedure "keV beam line of the Upgraded Injector Test Facility (UITF)" provides details for use of the following controls to mitigate exposures.

Table 3: Hazard controls in use at the UITF

Engineering controls:	Administrative controls:
○ Monitoring systems	○ Training
○ Ventilation	○ Procedures/Task Hazard Analysis
○ Pressure systems	○ Signs

Mitigations

Releases of SF_6 are monitored via the pressure within the SF6 tank that houses the Glassman gun high voltage power supply. There is a digital pressure gauge that monitors SF6 pressure, and can be configured to "alarm" when pressure falls below a User specified level. The alarm is a visual, yellow LED that illuminates at the SF6 tank. It will also trigger and EPICS signal to the control panel. The alarm is triggered when pressure drops from 60 to 58 psi. Finally, there is an Ashcroft pressure switch that will shut off the Glassman HV power supply when SF6 pressure falls below 45psi.

The UITF is also equipped with an oxygen monitoring system that alarms at 19.5% oxygen. While the quantity of SF_6 gas within the UITF would not trigger the ODH alarm due to the low concentration, the oxygen sensors are placed in the caves at floor and ceiling levels to detect other inert gases such as helium and nitrogen. Release scenarios of those gases are evaluated in a separate assessment (Oren, 2016).

Two exhaust fans are located in the UITF and are always on (except during building power failure) with duct openings located approximately 7 feet from the floor. One fan operating at 7400 cfm exhaust air from the UITF into the Test Lab High Bay. The other fan operating at 4400 cfm exhausts to the Test Lab roof. In case of release these fans would be used to help purge the UITF. An additional fan would need to be brought to the cave to provide mixing within the space. This fan will be placed on the floor at the cave entrance.

IH Conclusion

Oxygen deficiency hazard and potential TLV exceedance mitigations are well addressed through engineering and administrative controls for the UITF. While worst case scenarios have potential to exceed the TLV exposure limit, the gas properties and established controls reduce the hazard to workers in the UITF.

Using the Jefferson Lab risk code assignment system the overall risk rating for UITF, with hazard mitigations detailed in the OSP, is a risk code 1.

The ODH classification for the areas is designated to be ODH0. This classification requires workers entering the UITF to have ODH training (SAF103).

The resulting risk code and ODH classification are an acceptable risk for trained personnel.

References

ACGIH. (2005). *2005 TLVs and BEIs.*

Compressed Gas Association. (1999). *Handbook of Compressed Gases.* Kluwer Academic Publishers.

Oren, W. and Areti, H. (2016). *ODH Assessment, UITF.*

Praxair. (2015). *Safety Data Sheet, Sulfur Hexafluoride.*

(2001). *Sulfur Hexafluoride - TLV documentation.* ACGIH.